# 'Dual Fuel Technology'

#### **Background:**

- Currently commercially available from Clean Air Partners
- Available on Caterpillar on-road and stationary products
- Utilizes diesel fuel as ignition source to ignite natural gas (~10% over FTP)
- Utilizes port injection of natural gas charge rather than direct injection as in Westport HPDI
- Vehicles are currently running in multiple fleets
- 1000 Dual-Fuel units in service 2001

#### **Benefits:**

- Diesel engine based
- Higher thermal efficiency than SING
- Higher torque
- Retrofitable

#### What is Dual-Fuel™?

- Natural Gas with Diesel Pilot Ignition
- Fumigated w/ Mechanical Diesel
- Electronic Gas w/Mechanical Diesel

Electronic control of Gas & Diesel

Electronic Control . . . best performance





# **How the Dual-Fuel™ Engine Works**

- Electronically controlled, multi-point, port-injected
- Pilot ignition from the standard diesel fuel system
- Natural gas injectors and sensors combined with custom intake manifold

No internal modifications

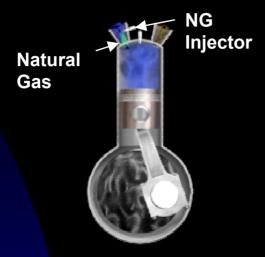
**CAP Digital NG Injector** 



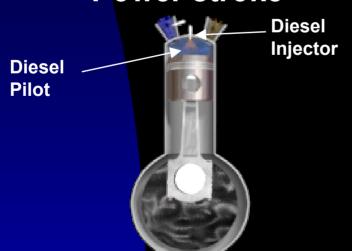


# **Dual-Fuel Cycle – In Action**

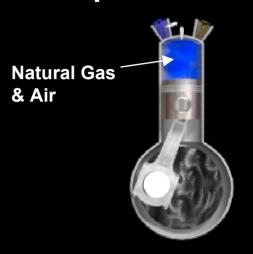
#### **Intake stroke**



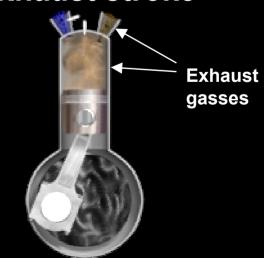
### Power stroke



## **Compression stroke**



#### **Exhaust stroke**





### **Dual-Fuel Applications: Mid-Range**

Two-axle van powered by a 3126B Dual-Fuel engine - CNG



City of Mexico City
City of Tucson
LA County Sanitation

Disneyland Veritable Vegetable Taormina Industries Caterpillar of Australia
DFW Airport
Kyrene School District



### **Dual-Fuel Applications: Vocational**

6x6 Dump Truck powered by a C10 Dual-Fuel engine



City of Santa Monica
City Of San Diego
H. E. B. Grocery

City of Tucson
Taormina
Clean Air Express

LA County Sanitation Jack B. Kelley
Sunline Transit Trucking Unlimited
STS / Pima Gro City of LA



## **Dual-Fuel Applications: Heavy-Duty**

Heavy-duty tractor powered by a C12 Dual-Fuel engine



Harris Ranch
Vons /Safeway
Luckys/Albertsons

Taormina
Fiba Canning
Warburtons

Empire
H. E. B Grocery
PNI Distribution

UPS NFZ Handel, AG SANDS Fridge Lines



# 'Dual Fuel Technology'

#### **Potential:**

- NGNGV project to demonstrate dual fuel capabilities
- Project Targets:
  - NOx emissions below 0.5 g/bhp-hr
  - •PM emission below 0.01 g/bhp-hr
  - Maintain efficiency of Cat® C-12 Dual-Fuel™ Engine
- Utilizes Clean, Cold, Low Pressure EGR and Catalyzed Particulate Trap

	Emissions Achieved (g/bhp-hr on ESC13)
NOx	0.54
NMHC	1.14
CO	0.05
PM	0.0037